Power Technology Branch
Army Power Division
US Army RDECOM CERDEC C2D
Aberdeen Proving Ground, MD

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CERDEC Fuel Cell Team: Military Transitions for Soldier Fuel Cells

Presentation for the 2008 Fuel Cell Seminar
27-30 October 2008, Phoenix, AZ

Marnie de Jong

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14. ABSTRACT

The Army?s Communications and Electronics Research, Development and Engineering Center (CERDEC) Fuel Cell Team, located in Fort Belvoir, VA and Aberdeen Proving Grounds, MD, is actively investigating fuel cell power sources from milliwatt to kilowatt levels to fit the Army?s power needs. Currently, many smaller fuel cell programs in progress at CERDEC use a packaged non-logistic fuel. Soldier and Man portable fuel cells combine the portability of batteries with the use of an external energy-dense fuel to fill the gap in power between batteries and generators. For this reason, CERDEC is actively working to assess the state of technology and attempt to field fuel cell power systems with several programs showing promise in providing reliable, small, and lightweight Soldier power solutions. This presentation will focus specifically on the development updates in the Soldier and Man portable power program areas. Over the past year several fuel cell power systems have been tested in CERDEC facilities. Also, many military exercises have been or are planned to be undertaken with the most technically mature systems.

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fuel cell, soldier power

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TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

CERDEC Fuel Cell Team: Military Transitions for Soldier Fuel Cells

2008 Fuel Cell Seminar – Phoenix, AZ
27-30 October, 2008

Marnie de Jong, JJ Kowal, Elizabeth Ferry, Jon Cristiani, Mike Dominick

Outline

- CERDEC Fuel Cell Team
  - ATO
  - Mission
- Completed Fuel Cell Testing
  - AMI Program and Testing
  - Ultracell Testing at Fort Polk
  - 250W Battery Charger Testing at Fort Dix
  - Protonex BAO Power Manager Testing
- Current and Future Efforts

CERDEC Fuel Cell Team:

Mission and ATO

Army Power Division
ATO

Army Power Division Mission: **Conduct research, development and system engineering leading to the most cost-effective power, energy, and environmental technologies to support Army's soldier, portable, and mobile applications.**

ATO D.CER.2008.08
Power for Dismounted Soldier

Half-Sized BA5590 Li/CFx Battery
Half-Sized BA5590 Li-Air Battery
Soldier Conformal Rechargeable Battery
Soldier Hybrid Direct Methanol Fuel Cell Power Source
Soldier Hybrid Fuel Cell Power Source
Portable Hybrid Power Sources & Chargers, JP-8 fueled

Soldier Fuel Cell Applicable

ATO R.LG.2009.01
Mobile Power

Transitional Hybrid Power Source, Log-fueled
Waste Heat Recovery
Power Centric Mobility applications

Technology Areas:

Soldier Hybrid Direct Methanol Fuel Cell Power Source

Soldier Hybrid Fuel Cell Power Source

Portable Hybrid Power Sources & Chargers (JP-8 fueled)

Technical Objectives

25W	1.5lbs	TRL 4/6
50-100W	3.5lbs	TRL 4/5
150-250W	25lbs	TRL 4/6

CERDEC Fuel Cell Team's Mission Areas

Mission: **Rapidly develop and transition suitable fuel cell technologies to applications where they are most needed.**

Soldier & Sensor Power
1W-100W

Man Portable Power
100W-500W

Auxiliary Power Units
500W-10kW

How to Work with CERDEC Fuel Cell Team

Broad Agency Announcement – W909MY-07-R-0016

FY09 Areas of Interest

50-100W Fuel Cell Hybrid Development - $~750K
Targets: **3.5lbs 1000Whr/kg TRL 5**

150-250W Man Portable Squad Charger - $~$500K
Targets: **25lbs TRL 6**

Submit white papers NLT 10 Nov.

Please also make sure to talk with the Fuel Cell Team while at the Seminar or Beth Ferry to make sure topics are aligned with Army Goals.

Fuel Cell Testing:

25W Systems

AMI 25W Alpha

In Development with CERDEC and DARPA

Rated 25W continuous
Solid Oxide Fuel Cell (SOFC)
Fuel: Commercial Propane Canisters

Dimensions:	**9.75” x 3.625” x 4.75”**
Start Up Time:	**9 min.**

System Dry Weight:	**2.1 kg**
Fuel Cartridge Weight:	**0.8-0.9 kg**

25W Mission Energy Density:

24 hr	**210 W-hours/kg**
72-hr	**460 W-hours/kg**

Orientation independent

Operated from -20 to 55 ^{o}C

Ultracell XX25

In Development with CERDEC and DARPA

Rated 25W continuous
Reformed Methanol Fuel Cell (RMFC)
Fuel: 67% Methanol / 33% Water

Dimensions:	**9.30” X 5.38” X 1.80”**
Start Up Time:	**20 min.**
System Dry Weight:	**1.2 kg**
Fuel Cartridge Weight:	**0.35 kg (250 mL)**

25W Mission Energy Density:

24 hr	**230 W-hours/kg**
72-hr	**380 W-hours/kg**

Orientation independent except upside down

Operated from -20 to 55 ^{o}C

Ultracell XX25/Ft Polk JRTC

Joint Readiness Training Center,
***Science and Technology Team* Mission:**

To keep soldiers who will soon be deployed informed on new technologies that will be fielded in the near future

Oct 2007 – 10 Ultracell XX25 units taken to JRTC and soldiers trained on their use.

Sept 2008 – Ultracell units replaced with newer version; units still operating seamlessly

Ultracell XX25/Ft Polk JRTC

Mission: **use XX25 to power Laptops in remote locations and SINCGARS radios for long duration missions**

Feedback:

Soldiers were pleased with lighter weight compared to batteries and showed acceptance of system for specific missions (OP)

Soldier concerns **were Safety, High Temperature Operation, and Integration with Applications.**

SOUTHCOM/PACOM Demos

AMI and Ultracell units will be used for various off grid military and humanitarian power applications in the Dominican Republic with the US Southern Command.

The units will also power military radios, rugged laptop computers, and other electronic devices in the Cobra Gold (CG) Demonstration.

The CG event will be in Thailand with the US Pacific Command Marine Experimentation Center around Feb 09.

Fuel Cell Testing: Fort Dix

250W Systems and Power Manger

Protonex 250W Battery Charger

Quick Reaction Funded

Rated 250W continuous
Reformed Methanol Fuel Cell (RMFC)
Fuel: 67% Methanol / 33% Water

Dimensions:	**10” x 14” x 20”**
(total 3 comp)	**(25 x 35 x 50 cm)**
Startup time:	**~25 mins**

System Weight:	**22.8kg**
Power Manager:	***5.3kg***
Fuel Cell:	***7.6kg***
Reformer:	***9.9kg***

***does not include fuel weight**

Idatech 250W Battery Charger

Mission Funded through ATO

250W Continuous Power
Reformed Methanol Fuel Cell (RMFC)
Fuel: 67% Methanol / 33% Water

Dimensions:	**12” x 8” x 14”** **(30 x 20 x 36 cm)**
Start-up time:	**~12 mins**
System Weight:	**11.3kg**

***does not include charging circuitry, fuel pump or fuel weight**

Fort Dix Testing

C4ISR on the Move Test Bed

Objective:

Venue for testing and evaluating new technologies in a relevant testing environment

Involvement:

Supported by Army Power and the Battery Branch for the past years by providing and charging military batteries

250W Fuel Cell Battery Charger Testing during week of 14-18 July

BAO Power Manager Testing during week of 14-18 July

Fort Dix Testing Results

Protonex

Charges 3 Batteries Simultaneously
Charging Circuitry designed into Fuel Cell System

Results:

Charging Time: **4-5.5hrs**

***significant variance due to runtime errors**

Fuel Consumption: **1.73kg avg (.577/battery)**

Further Testing to be completed

***NOTES: Errors in charging circuitry caused display to indicate batteries were full prematurely and halted further charging. Charging had to be recommenced manually. Upgrades to charging software necessary.**

Fort Dix Testing Results

Idatech

Charges 2 Batteries Simultaneously

Utilizes Bren-Tronics REPPS pack to complete charging

Results:

Charging Time: **2-5.5hrs**

***significant variance due to runtime errors**

Fuel Consumption: **1.11kg avg (.555/battery)**

Further Testing to be completed

***NOTES: Original charging set up failed during testing causing extended charging time. Charger set up was modified during final day of testing and produced better results.**

Protonex BAO Power Manager

AFRL program to develop a Battlefield Air Operations Power Manager (BAO□PM)

Objective:

Support power conversion and battery charging capabilities for the Air Force Battlefield Air Operations (BAO) Kit mission requirements

Dimensions:	**3.3” x 5.5” x 2.4”**
Weight:	**0.56 kg (1.2 lbs)**
I/O Ports:	**Three 30VDC nominal 12-34VDC, 20A**
Output Ports:	**Two 12-24V, 5A**
Scavenger Port:	**One 4-34VDC, 10A**

Protonex BAO PM Ft Dix Testing and Results

Tested at Fort Dix, 14-18 July 2008

Testing Equipment included:

MicroSun 30V battery
55W Solar Panel
Ultracell XX25
BB2590
Li-145
MBITR
IBM ThinkPad
cables and chargers

Results: Power Manager Performed favorably – some electronic glitches need to be worked, most notably needs to be able to operate with only BB2590 as input source.

Wearable Power Prize Challenge

29 Palms, CA

Wearable Power Prize Challenge

WPP Challenge Goals:

- **Capable of providing 96 hours of operation**
- **20W average power with 200W peaks**
- **Weigh 4kgs or less**
- **Attach to vest (wearable)**

Winning Companies- all received previous CERDEC support:

(1) **Dupont/Smart Fuel Cell: *M-25 Fuel Cell System***
(2) **Adaptive Materials Inc.**
(3) **Capitol Connections/Smart Fuel Cell: *Jenny 600S***

***CERDEC invested in all five of top placing companies (4 – Ultralife, 5 - Ultracell)**

CERDEC Fuel Cell Team:

Current Efforts

Current Fuel Cell Team Efforts

AMI: 25W Solid Oxide Fuel Cell (SOFC)

Ultracell: 25W Reformed Methanol Fuel Cell (RMFC)

Smart Fuel Cell: 20W Direct Methanol Fuel Cell (DMFC) (PEO Soldier)

Samsung: 20W DMFC (CRADA)

General Atomics & Jadoo: 50W Ammonia Borane Fueled PEMFC

Current Fuel Cell Team Efforts Continued

Ardica: 20W Wearable PEMFC operating on Chemical Hydrides

Spectrum Brands w/ Rayovac: Hydrogen Generators and Alkaline Fuel Cells for AA applications

Akermin: 50mW Enzymatic Biofuel Cell

UNF w/ Polyfuel & UF: 15W Direct Methanol Fuel Cell

Current Fuel Cell Team Efforts Continued

EBA&D: 100W Ammonia Borane fueled PEMFC

Ultralife: 150W sodium borohydride fueled PEMFC

Protonex: 250W RMFC and Power Manager (ARO)

NanoDynamics: 250W SOFC fueled with desulferized JP-8

TTU: Advanced Portable Power Institute

Current Fuel Cell Team Efforts Continued

Altex Technologies Corporation

ASPEN PRODUCTS GROUP, INC.

Idatech: 3-kWe steam-reforming PEMFC running on JP-8 / diesel fuel & 250W RMFC

Aspen: 5kWe integrated desulfurizer and JP-8 / diesel fuel processor

Altex: 2-kWe integrated desulfurizer and JP-8 / diesel fuel processor

Precision Combustion: 5-kWt integrated desulfurizer and JP-8 and diesel fuel processor

Precision Combustion, Inc.

IdaTech

Customers

Partners

Conclusions

- **Test and evaluation of fuel cell power systems plays a vital role in assessing the state of technology, and providing feedback to shape solutions to fulfill military requirements**
- **Many current systems have increased reliability and ruggedness to survive military environments and work has started to progress from laboratory prototypes to fieldable systems**
- **No one technology has shown it will be the sole solution for the military**

THANK YOU!

Questions??